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EXPERIMENTAL INVESTIGATION ON LINSEED OIL METHYL ESTER FUELLED DIESEL ENGINE

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ABSTRACT

The look for an alternative fuel has prompted numerous discoveries because of which a wide assortment of alternative energizes are accessible available to us now. On the basis of fossil fuel energizes around the world never just brought about the consumption of traditional sources of energy supplies. Transesterification is one of the technique which utilizes ethanol or methanol, within the sight of an impetus, for instance, catalyst like potassium hydroxide or sodium hydroxide in order to split the particle of the oil into a glycerol and ester. For compression ignition engines, the Methyl Ester of Linseed oil (MELSO) which is tolerating extending thought as an elective fuel. In the present research, raw linseed oil is changed into their particular methyl ester all the way through transesterification method. Biodiesel is a non-hazardous, eco-friendly and sustainable fuel with the possibility to lower the exhaust emissions of the engine. In the present exploration, the blends of altering proportions of linseed oil without transesterification and transesterification of linseed oil blends be used to run a single cylinder diesel engine with DC generator, furthermore evaluated the performance parameters of the biodiesel imitative from non-edible linseed oil in a diesel engine.

KEYWORDS: ***Transesterification, Diesel Engine, Linseed Oil & Performance parameters***

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Original Article

INTRODUCTION

The utilization of bio-diesel (vegetable oils) is substituted hotspot for fossil fuel. It was also evident that biodiesel was the better trade off energy, in fact, naturally worthy, monetarily focused and effectively accessible. India is bringing in rough oil and oil based commodities from Gulf nations. Indian researchers scanned for another energizes in order to safeguard from worldwide condition, also to endure from the financial emergency [1]. The main problem which is associated with the plant oil is its high thickness and these plant oils has incredible characteristics, in any case they create challenges, for instance, poly unsaturated characters, low volatility, lower heating value, higher stability, lower solidness and greater viscosity. If plant oil can be used directly in the compression ignition engine, as a result, there is a reduction in efficiencies of the compression ignition engine. Such concerns can be remedied through different procedures to diminish the consistency of plant oils. The major techniques involved are weakening and breaking strategy. Another major method which is used to decrease the viscosity of the oil is transesterification. This transesterification method improves thermal efficiency of the engine[2]. Compression ignition (CI) engines play a key role in shipping, and control parts because of its roughness along with superior efficacy. In the wake of present energy

situation, significant research is centered around low-cost vitality arrangement with real accentuation on vitality efficiency and utilization of sustainable power supplies [3]. There are severe natural standards have been commanded in favor of a sustainable option in contrast to fossil fuel. Notwithstanding, worries regarding extended haul accessibility of fuel[4]. The conversion of plant oil into methyl or ethyl ester by means of transesterification process provides better execution in contrast with direct plant oil [5]. Adjustment which is essential in the motor structure must be made in such a route in order to limit the speculation cost in the engine alteration. An extensive assortment of elective energizes are viewed as possible substitute to oil based diesel, in any case, adjustment, ease of manufacture, take care of shipping and venture cost was a portion of the significant variables that ought to be measured prior to utilizing the elective oil in a current compression ignition engine. Fluid bio-inception fills are sustainable energizes originating from organic supplies. These energizes will increases for overall acknowledgment of ecological debasement, vitality security, confining import, rustic work and agrarian economy [6]. Utilizing the blends of CalophyllumInophyllum (punnai) biodiesel along with added substances were tried in a compression ignition engine and evaluated performance characteristics. From the test results it is demonstrated that there is reduction in specific fuel consumption, and increase in brake thermal efficiency [7]. The plant oil crops which are developed in badlands are not reasonable as sustenance. Numerous inquires in relation to determined are centered around plant oils which are not appropriate in case of human being utilization because of the nearness of harmful parts posses in the lubricate [8]. Utilization of the blend B20, the emissions are very lesser and performance characteristics are very higher for the Compression ignition engine. From the results, B20 is the optimum fuel [9]. Linseed oil displays high blaze point which is used to help in taking care of, capacity and great oxidation dependability. Ester-based energizes are usually referred as a biodiesel by and large characterized as the mono-alkyl esters produced using vegetable oils, for example, linseed oil and canola oil by a method of transesterification.

LINSEED OIL AS A POSSIBLE ALTERNATIVE FUEL FOR CI ENGINE

As of late, many researchers were tried to use various vegetable oils which is produced from the fuels, used in compression ignition engine. Pascal and Mohan [10] utilized palm oil in compression ignition engine by means of waste cooking oil, in which it was converted into esters through a method of transesterification. From the test results, it was evident that increment in brake thermal efficiency for the palm oil with diesel blends. Puhanet al. [11] detailed that the emissions that are produced by the methyl ester of Mahua oil (B100) is lesser when contrasted with slick diesel (B0) in a direct injection compression ignition powered fuelled motor. Gumus and kasifoglu [12] investigated that the apricot seed methyl ester was produced from the apricot seed piece oil through a method of transesterification process by utilizing methanol in occurrence of catalyst like potassium hydroxide. The obtained apricot methyl ester and its mixes with diesel fuel were tried in a compression ignition engine and evaluated the performance and emission parameters. Sahoo et al. [13] utilized polanga oil which is high corrosive and high viscosity. The obtained plungeethyl ester oil blends with diesel and it was used to run in a single cylinder compression ignition engine and explored the performance characteristics of an engine. Sharanappa Godiganur et al. [14] explored the utilization of Mahua oil methyl ester obtained from the crude Mahua oil by means of transesterification technique. The various proportions of Mahua oil methyl ester and its blends with diesel fuel were used in a diesel fuelled engine. From the test results, it was clearly observed that the blend B20 blend gives better performance characteristics and lower emissions. Kegl [15]utilized the rapeseed oil and its blends mixes with diesel fuel in a diesel powered engine and determined the emission characteristics and their aim of the research is to reduce

the harmful emissions by using rapeseed oil as biodiesel on the injection and spray. From the test results it was observed that the emissions that are produced by the rapeseed biodiesel are less harmful to some extent by adjusting injection pump timing properly. Fen et al. [16] arranged waste cooking oil based ester through a method of transesterification. The blends of waste cooking oil and its blends which was obtained by transesterification technique mixes with diesel fuel in a CI powered engine and calculated the engine performance characteristics. From the test results, it was clearly noticed that the Blend B20 and B50 are the ideal fuel blends. Taymaz et al. [17] prepared palmolein and soybean vegetable oil were converted into their respective ethyl ester through transesterification process. The blends of the palmolein and soybean ethyl ester mixes with diesel fuel and they were used to run on a direct injection diesel engine, also evaluated the engine performance and exhaust emissions of a diesel engine. From the test results of their experiment, it was evident that torque and brake power output of the engine were comparatively lower than the diesel and also found that specific fuel consumption was higher compared with the diesel. Agarwal et al.[18] revealed that the biodiesel was used to run a compression ignition engine and determined the emission characteristics of a engine. From the test results it was observed that the biodiesel produces unburned hydrocarbon, less carbon monoxide, and less particulate emissions contrasted with the neat diesel fuel, it was also noticed that it produces higher NOX emissions. Bueno et al. [19]utilized the soybean oil ethyl ester obtained from the neat soybean oil by means of transesterification method. The blends of alternate proportions of soybean ethyl ester and its blends mixes with diesel fuel and used to run in a CI fuelled engine, and they determined the performance characteristics of a diesel engine. From the test results it is evident that increment of Brake thermal efficiency with the blend B20. Under the similar conditions, there is a decrement in specific fuel consumption and brake power with B10 blend. Uddin et al. [20] prepared the various proportions of neat mustard oil blends with kerosene fuel in the percentage of 20%, 30%, 40% and 50% and 100%, tested at various load conditions, and determined the impacts of performance characteristics of the compression ignition powered engine. From the test results, it showed that the brake specific fuel consumption is lower in case of the blend B20 and B30 at the load of 12.5 kg. Singh et al. [21] arranged the alternate proportions of mustard oil with diesel fuel blends, were used to run on internal combustion engine and deliberated the performance characteristics of CI engine. From the results, it is demonstrated that 8% of the fuel mix exhibited great effectiveness without any alternations. SenthilKumar and GopalaKrishnan [22] prepared the biodiesel blends of mustard oil methyl ester and jatropha biodiesel blends at different proportion, they assessed the performance, combustion, emission characteristics of the compression ignition fuelled diesel engine at various engine loads. From the experimental results, it was showed that brake thermal efficiency was greater when compared with that of diesel for all engine loads. Santhan Kumar and Ravikumar [23]utilized the blends of the corn oil with the diesel fuel at alternate proportions and deliberated the performance, combustion and emission characteristics of a compression ignition (CI) engine. From their results it is demonstrated that the corn oil was used as fuel, there was decrement in filter blockage issue. Murayama T. [24]arranged the blends of cotton seed oil based monoesters with the diesel fuel blends were used to run diesel fuelled CI engine. In this research work, vegetable oil is converted into monoester through transesterification method. From their test results, it is demonstrated that the engine parameters required few corrections for attaining most extreme power output and maximum thermal efficiency. It was also showed that without any modifications in the engine, cotton seed oil can be used as fuel in compression ignition engines. Banapurmath NR et al. [25]utilized the blends of honge, neem and sesame oil methyl esters as a fuel along with the diesel fuels were used to run in a direct injection diesel

powered engine, determined the performance and emission attributes for the DI diesel engine. From their experimental results, explored that performance characteristics of the blends were almost similar to that of the engine uses diesel as a fuel. Balamurugan and Nalini [26]examined that there is a decrement in engine power because, the thickness of the biodiesel is greater. Additionally increment in specific fuel consumption due to lower calorific value of the biodiesel as a result combustion temperature decreases. Agarwal Deepak et al.[27]utilized the various proportions of diesel as a fuel with Mahua and linseed oil blends were used to run on a compression ignition powered fuelled engine and determined the performance attributes of a diesel engine, their test results exhibited that increment in thermal efficiency at the blend B30 with Mahua oil and decrement in specific fuel consumption at the blend B50 with linseed oil. Ozsezen et al.[28]arranged the blends of canola oil methyl esters which is obtained by a method of transesterification, waste palm oil along with diesel as a fuel in a direct injection diesel engine and explored the performance and ignition characteristics of the DI diesel engine. From their test reports it is showed that without any modifications waste palm oil and canola oil methyl esters can be used in a DI diesel engine.

Table 1: Composition of Fatty Acids [34,35,36]

Fatty Acid	Synthetic Name	Structure	Formula
Palmitic	Hexadecanoic	C16:0	$C_{16}H_{32}O_2$
Stearic	Octadecanoic	C18:0	$C_{18}H_{36}O_2$
Oleic	Octadecenoic	C18:1	$C_{18}H_{34}O_2$
Linoleic	Octadecadienoic	C18:2	$C_{18}H_{32}O_2$
Linolenic	Octadecatrienoic	C18:3	$C_{18}H_{30}O_2$

Fossil fuel mainly consists of poly unsaturated characters and several distinctive long chain hydrocarbon atoms. It also contains unrefined petroleum buildup harmful substances. On the other hand, the fossil fuel has unique relation with the composition of fatty acids[29]. A portion of the plant oils characteristics are unique in relation to creature fats due to their source. Oil from green growth, microscopic organisms and parasites additionally has likewise been explored [30]. plant oils mainly consists of 3% of mono-glycerides and di-glycerides and 97% of triglycerides [31]. The way toward changing over plant oilinto monoester, which is known as transesterification process. This process utilizes liquor in occurrence of impetus[32]. Breaking points and softening purposes of the unsaturated fats, esters and glycerides augments as the amount of carbon particles in the carbon chain increase, anyway decay with addition in the quantity of twofold securities[33]. Composition of fatty acids is shown in Table1.

PRODUCTION OF LINSEED OIL AND PROPERTIES

Linseed Oil Production

The linseed oil production is made through transesterification technique. Transesterification is where linseed oil responds with alcohol like methanol or ethanol in event of impetus like potassium hydroxide (KOH). In the midst of this technique, the particle of linseed oil is chemically broken to outline methyl ester of linseed oil (MELSO). After that the biodiesel is cleaned to confine from glycerol. In present work, it is indisputably looked for 1000 ml of raw linseed oil, responds with methanol (250 ml) and potassium hydroxide (10 grams) at temperature of 70^0C produces a limit of 800 ml methyl ester of linseed oil (MELSO).

Properties of Linseed Oil

A Progression of tests are performed to depict the properties of the delivered linseed biodiesel. Diesel fuel and linseed oil/ester properties are shown in Table 2

Table 2: Diesel and Linseed Oil/Ester Properties

Properties	Diesel	Linseed Oil	Methyl ester of Linseed Oil
Density (g/cm^3)	830	920	865
Kinematic viscosity at 40^{0}C (centistokes)	2.7	26.3	4.2
Calorific value (KJ/Kg)	45350	39307	40759
Specific gravity	0.834	0.95	0.865
Flash point (^{0}C)	53	232	165
Fire Point (^{0}C)	62	240	172

EXPERIMENT

In this exploration, 4-stroke compression ignition fuelled engine with DC generator loading having 5HP as rated power at 1500 rpm is used. Experimental setup is demonstrated in Figure 1. The stream rate of the fuel is estimated on the volumetric premise utilizing stopwatch and burette. The type of the CI engine is water cooled. Diesel engine specifications is demonstrated in Table 3. The tank is filled with the raw linseed oil blend taken. The pipe should be checked that there should be no air bubbles and the pipe is connected to the engine. The decompression switch is proceeded so that there will be no air getting amidst barrel and the chamber. At that point motor is to be commenced and it is permitted to get the speed, easily for a couple of moments. By means of the tachometer, speed of the engine is estimated. Now take down the voltmeter, ammeter readings, time taken for utilization of fuel on no load conditions and perusing of manometer. At that point the motor is stacked by gradually bringing down the copper plate in water rheostat. In the wake of applying of burden on the motor at set point, take down the readings. A similar method is rehashed for various values. Different blends of linseed oil with diesel such as 10% linseed (linseed-10% and diesel-90%), 20% linseed (linseed-20% and diesel-80%), 30% linseed (linseed-30% and diesel-70%), 40% linseed (linseed-40% and diesel-60%) and 50% linseed (linseed-50% and diesel-50%) be arranged and tried for its performance characteristics. Same procedure is continued for transesterification of linseed oil with different blends.

Table 3: Diesel Engine Specifications

Make	Kirloskar Make, Compression Ignition with D.C. Generator
No. of cylinders	one
Bore	80 mm
Coefficient of discharge (C_d)	0.62
Capacity	4 KW
Diameter of Orifice (d)	20 mm
Stroke	110mm
Compression ratio	16:1
Maximum Current	13 amps
Efficiency of dynamometer	80%
Armature voltage	220V

Figure 1: Experimental Setup

RESULTS AND DISCUSSIONS

Brake Specific Fuel Consumption

From the figure 2 it is noticed that the brake specific fuel consumption of the engine with B20 blend is lower compared to B10, B30, B40, B50 and diesel. This is mainly caused by greater thickness and lower gross calorific value of the raw linseed oil. The effect of Brake specific fuel consumption (BSFC) of raw linseed oil and its blends with respect to brake power is demonstrated in Figure 2.

The greater density of the methyl ester of linseed oil (MELSO) has prompted more release of fuel for a similar dislodging of the plunger in the fuel infusion siphon, consequently expanding the utilization of fuel. The brake specific fuel consumption in case of methyl ester of linseed oil (MELSO) blends are greater than the diesel and it is shown in Figure 3. It is observed that blend MELSO50 has lower BSFC which is closer to diesel.

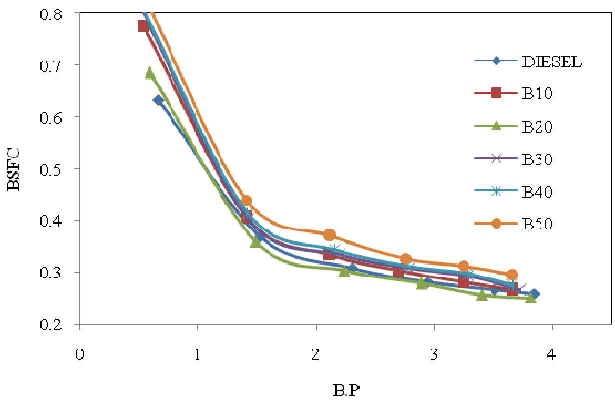

Figure 2: Variation of Brake Power with Brake Specific Fuel Consumption (without Transesterification)

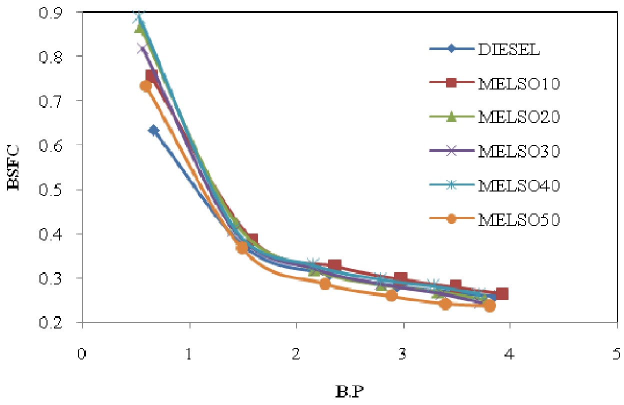

Figure 3: Variation of Brake Power with Brake Specific Fuel Consumption (with Transesterification)

Brake Thermal Efficiency

Figure 4 indicates that increase in brake power of the engine, increases in brake thermal efficiency of the engine. In other words it could be assumed that brake power is directly proportional to the brake thermal efficiency. Generally brake thermal efficiency is defined as, it is the ratio of brake power to the heat input. From the figure it is evident that linseed oil without transesterification blend B20 has greater brake thermal efficiency. Rapid flaming is the main reason for improving the thermal efficiency.

From the test results of the Figure 5 The brake thermal efficiency of methyl ester of linseed oil (MELSO) with diesel gradually increases with increase in brake power of the engine. It is also evident that the MELSO50 has greater brake thermal efficiency. The possible reason for this increment is better ignition characteristic and vaporization.

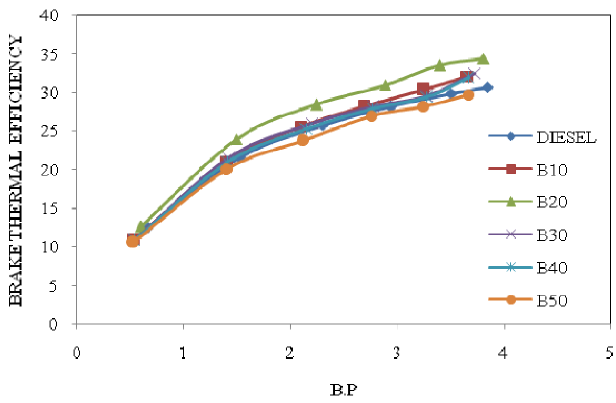

Figure 4: Variation of Brake Power with Brake Thermal Efficiency (Without Transesterification)

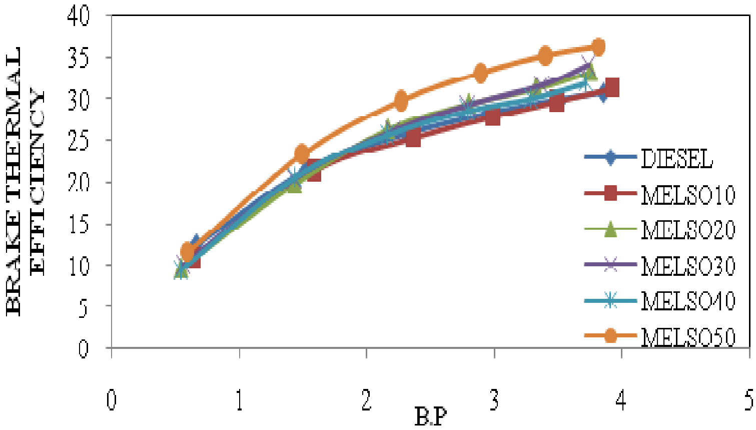

Figure 5: Variation of Brake Power with Brake Thermal Efficiency (with Transesterification)

Indicated Thermal Efficiency

The ratio of indicated power of the engine to the thermal input is called indicated thermal efficiency. The effect of brake power with the indicated thermal efficiency (without transesterification) is demonstrated in Figure 6 The indicated efficiency of the B20 blend has higher in contrast to diesel and all other blends.

Indicated thermal efficiency (with transesterification) plots in Figure 7. It shows that the brake power of the engine increases, indicated thermal efficiency of the MELSO blends increases. Indicated thermal efficiencies of the MELSO mixes are greater in contrast with diesel. It is evident that MELSO50 has greater indicated thermal efficiency.

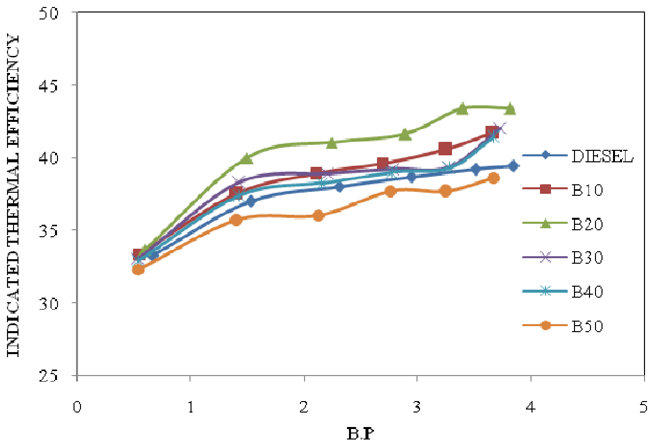

Figure 6: Variation of Brake Power with Indicated Thermal Efficiency (without Transesterification)

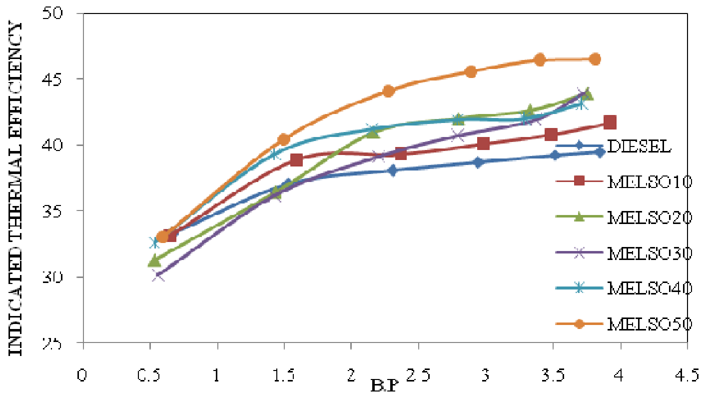

Figure 7: Variation of Brake Power with Indicated Thermal Efficiency (with Transesterification)

Mechanical Efficiency

The Mechanical efficiency (without transesterification) plots in Figure 8. Mechanical efficiency is defined as brake power divided by indicated power. Since indicated power never equal to the brake power because that happen only in case of ideal condition but in actual every engine has some kind of loss which is friction etc. From the figure it is evident that B20 has greater mechanical efficiency in contrast to diesel.

From the Figure 9 it is evident that the mechanical efficiencies of the (MELSO) methyl ester of linseed oil blends are slightly less in contrast to diesel. The blend MELSO50 has better mechanical efficiency which is closer to diesel.

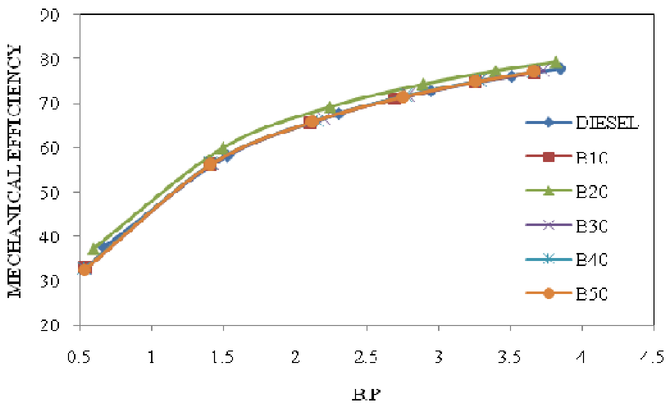

Figure 8: Variation of Brake Power with Mechanical Efficiency (without Transesterification)

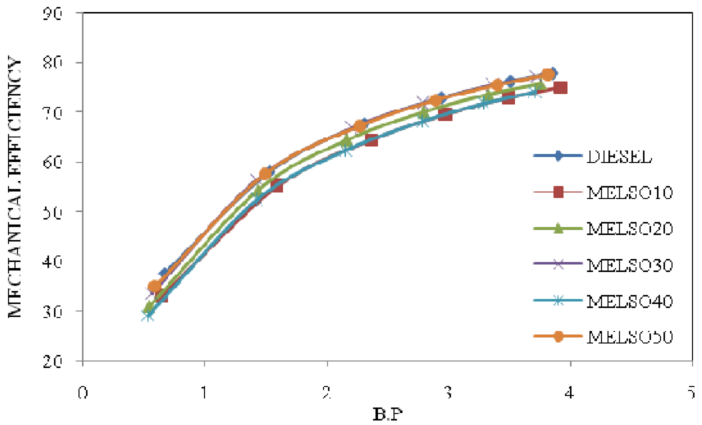

Figure 9: Variation of Brake Power with Mechanical Efficiency (with Transesterification)

Volumetric Efficiency

The effect of volumetric efficiency in contrast to brake power (without transesterification) is demonstrated in the Figure 10. In general, volumetric efficiency is defined as air volume sucked into the engine divided by cylinder's swept volume. Since piston moves towards BDC in power stroke but the volume it sucks from outside is not the same it has swept while expanding. From the figure it is clearly evident that volumetric efficiency of all the blends are lower in contrast with diesel.

From the Figure 11 It is noticed that volumetric efficiencies of (MELSO) methyl ester of linseed oil blends are greater in contrast with diesel.

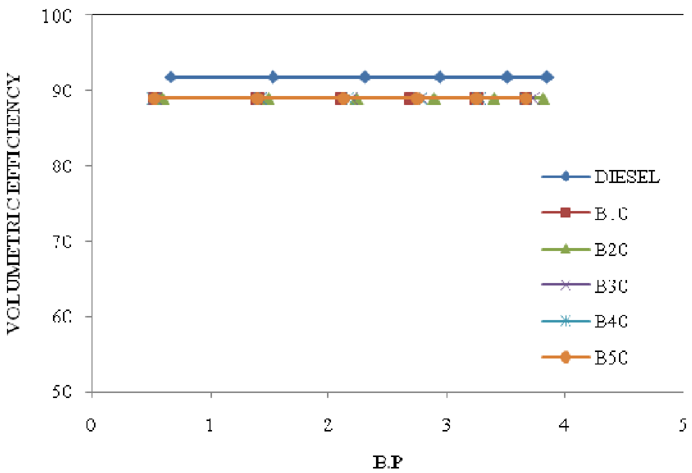

Figure 10: Variation of Brake Power with Volumetric Efficiency (without Transesterification)

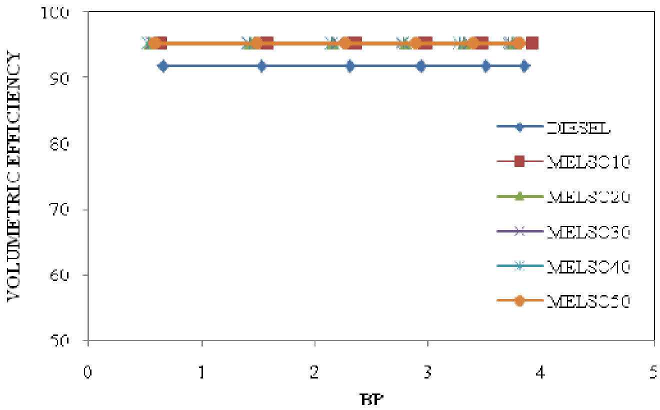

Figure 11: Variation of Brake Power with Volumetric Efficiency (with Transesterification)

CONCLUSIONS

While operating single cylinder compression ignition engine with & without transesterification of linseed oil blends, the conclusion as follows

- The properties of linseed oil are nearer to the diesel through transesterification process.
- The brake specific fuel consumption reduces for transesterification of linseed oil at all loads. At MELSO50 for transesterification of linseed oil, the amount of reduction of BSFC is more.
- The brake thermal efficiency at all blends for transesterification of linseed oil is greater than the linseed oil without transesterification blends. At B20 the brake thermal efficiency for the linseed oil without transesterification is effective when compared to other blends. At MELSO50 the brake thermal efficiency for the transesterification of linseed oil is effective compared to other blends.
- The indicated thermal efficiency at all blends for transesterification of linseed oil is greater than the linseed oil without transesterification blends. At MELSO50 the indicated thermal efficiency for the transesterification of linseed oil is effective compared to other blends. At B20 the indicated thermal efficiency for the linseed oil without transesterification is effective compared to other blends.
- The mechanical efficiency for the transesterification of linseed oil is slightly less than the linseed oil without transesterification because of the high frictional power and engine stability.
- The volumetric efficiency for the transesterification of linseed oil is greater than the linseed oil without transesterification at all fuel blends. By using the transesterification of linseed oil, the volumetric efficiency increased by 6.2% when compared with linseed oil without transesterification.

Finally we conclude that by transesterification of linseed oil fuelled with diesel engine, the efficiencies of the engine can be improved and the amount of fuel consumption can be reduced.

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